SPECIAL FOMES ISSUE.

THE ENTOPATH NEWS.

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INTRODUCTORY

We are taking the unusual course of devoting a whole number of Entopath to a single subject. We regard the fungus Fomes annosus, both as a cause of killing and more particularly as a cause of butt-rot, as the most serious disease now facing us. Dr. Rishbeth at Cambridge has elaborated a method of stump treatment which has been in operation in the pine forests of East Anglia for several years. We believe that it would greatly lessen the development of Fomes if this practice were extended to conifer plantations in other parts of Britain. Our main purpose in this number is to explain how Fomes spreads; to give some idea of the serious losses it causes; to present the reasons for stump treatment and to describe the method of doing it. We would like to stress that this is not intended as an instruction to start stump treatment. That naturally must wait on your Conservator's decision. But if you are asked to start, we hope that the background knowledge in this issue will prove helpful in carrying-out the operation, and that it will assist you to understand the basis for it and to appreciate how important it is that it be done well.

As you know, "Entopath" is generally anonymous. We would like to mention, however, that for this issue we have received assistance and advice from Dr. Rishbeth at Cambridge and from Mr. Dowden at Aberdeen who has commenced work on economic losses.

THE GENERAL BACKGROUND.

Fomes annosus has a long history, appearing in much of the early Continental literature under the name Trametes radiciperda. Both its killing and butt-rotting activities were discovered at an early stage. It soon attracted attention as the cause of death of pine, mainly Pinus pinaster, playing the same role as it now does

in East Anglia. This was generally referred to as 'La Maladie du Rond'. Comparatively little attention, however, was paid to the decay it causes, and it was not till the Nineteen-thirties that Fomes came to be recognised as a major source of loss in this respect both in Britain and in Scandinavia. In the rest of Europe it has received much less attention. This may partially be due to the conservative thinning policies followed in the past, whereby not enough stumps were provided for its active development. Many Continental workers would take the view that Fomes thrives only in what they regard as 'unnatural' plantations of pure conifers and that 'natural' woods, particularly mixed ones, will stay more or less free. The idea of infection of thinning stumps, and spread thence via roots, which is the basis of stump treatment and which is explained in greater detail below, is only now becoming accepted on the Continent. We can only say that the more evidence we collect, the more support we get for this explanation of the spread of Fomes, and that control measures based on this concept have proved very effective.

In the United States Fomes was hardly noticed before 1940. From then on it attracted increasing attention, first in plantations and more recently in natural stands. But even now Fomes is far less important in the U.S.A. than in northern Europe.

In Britain a widespread survey carried out in the nineteen-thirties showed clearly that Fomes was far more important as a cause of decay than all the other conifer-rotting fungi put together. A few years later serious group deaths in the East Anglian pine areas, emphasised its importance as a killing agent. The butt-rot survey also showed that most of the Commission's plantations on virgin ground were unaffected. Most unfortunately this lulled us into a sense of false security. Now it is realised that these areas are liable to infection and that the methods which have proved successful in East Anglia should be applied elsewhere. This number of Entopath reflects a need to take action now, before it is too late.

HOW FOMES WORKS.

Basically, the method of infection is a simple one. Wind-blown spores, after alighting on cut stumps, germinate, and the developing mycelium grows down into the root system and, where root contacts occur, passes into neighbouring trees causing either butt-rot or death. The extent to which this happens is very much subject to outside influences, however.

Fomes is a wood-rotting fungus chiefly inhabiting stumps and roots. It does not grow freely through soil and its local spread is confined to roots, passing from one root system to another only when there is contact or fusion. The commonest initial sources of infection are conifer stumps, but stumps of hardwoods such as birch are sometimes implicated. Fomes is thus virtually absent from sites without trees or stumps, such as moorland and formerly arable ground, and plantations established on them become infected only when trees are cut down. Infection occurs most frequently after thinning, but also after rack-cutting and minor operations such as cleaning.

The characteristically bracket-shaped sporophores are mostly formed on stumps or dead trees near ground level when the air is sufficiently humid, but they also occur on roots, especially in burrows or in cavities under trees tilted by the wind and in the hollow centres of old stumps.

Wider dispersal of Fomes, as opposed to local spread, is achieved by spores which are minute and capable of being carried considerable distances by wind; these spores may settle on the freshly cut stump surface and under suitable conditions germinate. This point is of paramount importance. Spores may be liberated at any time of year. The chance of stump infection by Fomes is determined by many factors including the proximity of spore sources, wind direction and the relative abundance of spores of competing fungi. Oddly enough dry weather is particularly liable to lead to stump infection by Fomes since spore production of this fungus is much less affected by drought than that of its competitors. Spores may also infect brashing wounds where living wood is exposed, but this is a far lessserious risk than stump infection, especially with pines.

Within a year or two of felling in the case of moderate-sized stumps, Fomes can grow down through the root system of the stump and infect living roots of surrounding trees. The outcome of/

of such infections varies greatly, for instance with site, species and age. At one extreme, as with pines on light soils formerly cultivated, excellent conditions exist for Fomes development and root systems may be progressively invaded and trees killed from the third or fourth year onwards, sometimes for many seasons. Characteristic groups of dead trees appear and Fomes may spread radially at rates up to 2 feet per year. Where infected stumps are more heavily concentrated, as sometimes happens in racks, the disease may be even more severe, involving rates of spread of up to 4 feet per year. By contrast, killing is usually of minor importance on sites not formerly cultivated and having more acid soils. Killing may occur with any conifer species and with a variety of hardwoods too; but broadleaved species are more resistant to attack, and it is normally only in heavily infected areas, in mixture with conifers, that they are killed. The fact that deaths are more commonly seen in pines is partly because this species is the most suitable choice for light-textured soils, at least in dry areas.

On sites not favouring outright killing, pines and to a lesser extent Douglas fir and Abies tend to confine the parasite to the roots and the extent of infection may become apparent only after wind-throw. With larches and spruces and some other conifers, however, rot originating in the roots usually progresses into the butt and there develops to a varying extent, sometimes 'pumping' the tree. Here the extent of damage is commonly revealed at thinning, but without detailed investigation spread from infected stumps would hardly be suspected. Butt-rot is far more prevalent than killing in the country as a whole and occurs on a wide variety of sites: it differs from killing in tending to increase in severity with age, rather than to diminish and is of considerably greater economic importance.

It stands to reason that second-rotation crops are more subject to Fomes attacks than first-rotation ones because sources of infection are often present from the outset. At the time of felling infected stumps may be scattered throughout the area and stumps of the final crop, if they do not already have root infections, may become infected by wind-borne spores. After replanting, infections commonly result in the death of some young trees, but more serious in the long run, with susceptible species, is the early establishment of root infections capable of producing/

producing butt-rot. Although Fomes is often replaced by other fungi it may survive for many years: instances of survival in large stumps for periods of over 50 years are well authenticated in several parts of the country. Control by eradication thus presents formidable problems and so, with the risk of stump infection now so widespread in the country, there is an excellent case for trying to prevent Fomes becoming further established in our forests.

WHY TREAT STUMPS?

For initiation of new Fomes infections, the freshly cut stump can be regarded as the 'Achilles heel' of a conifer plantation. If unprotected, it serves as an ideal medium for growth of the parasite; indeed stumps of some conifers, especially pines, are highly selective in the sense that Fomes can colonise them readily whereas most other fungi, even if present in greater numbers, cannot. The whole point of treating the freshly cut stump surface is to destroy this selectivity for Fomes. It is not fully understood how various protectants work, but creosote probably creates a toxic barrier, preventing all except very occasional penetration by Fomes.

The use of stump protectants for first rotation forests will keep out Fomes, but for areas which are already infected it may at first appear to be of little value. In fact, unless the disease has progressed to a stage where most of the crop is affected, stump treatment is well worthwhile to limit build-up. Underground spread of the disease will continue, but this is normally a slow process, and the prevention of new stump infections will limit its overall strength. Furthermore it will help to restrict the production of sporophores, which themselves aid build-up.

Where pure pine is to be employed in a forest it may be argued that as, on the vast majority of sites, death from Fomes will never become a serious problem, there is little point in keeping the fungus out. This is only valid if pine is to be used for following rotations, for if butt-rot susceptible conifers are substituted in the future they will be subjected to infection from the contaminated pine stumps. Where pine is mixed with other species it will usually be necessary to treat it in order to protect the remainder, unless these are only a small part of the crop and do not justify the expense.

METHOD OF STUMP TREATMENT.

At the moment the use of chemicals, although promising, is still in the experimental stage and creosote is the best recommendation we can make. Thanks largely to the pioneering work of Mr. Backhouse and his staff in East Anglia we know that creosote can be an efficient and inexpensive stump protectant, and during the period of its use we have learnt something of the practical problems involved. Some creosotes are not nearly so effective as others. Adulteration of the creosote must be avoided. Two other important causes of breakdown have emerged, insufficient application and delay in application.

It is false economy to make the creosote cover the maximum area. What is wanted is copious application in order to get good penetration. While too much run-off over the bark would be wasteful, some waste is preferable to a too-light application. Care must be taken to avoid missing any bare wood including axe cuts and in particular jagged breaks. With material costing approximately one fifth of the total and labour the rest, the obvious aim is to do the job as quickly as possible and not to be overcareful with the material. A short-handled tar brush with soft bristles, holding a large volume of material is suitable. In East Anglia the pot and brush method has proved satisfactory; but now that protection is being extended into other parts of the country the hilly nature of many forests may present difficulties and a non-spill bucket or small hand pressure spray may provide a better answer.

Regarding time of application it has been found that, although quite good protection can be afforded by treatment the same day as the felling, breakdown sometimes occurs, particularly where resin production from the cut surface interferes with creosote penetration. The possibility of spores being carried some distance into the wood by rainfall is another reason for avoiding delay and in practice what must be aimed at is <u>immediate application</u>. The men felling the trees should carry the creosote with them and treat as they go. This will avoid going over the ground twice and eliminate the difficulty of stumps becoming covered before treatment when a series of trees are felled. A few untreated stumps left covered over with debris can still let infection in.

Creosote for timber preservation to British Standard No. 144, a grade for brush application, will meet requirements. Some local gas-works/

gas-works creosotes are poor, some are very good, but if a creosote known to be effective for timber preservations is used results should be quite satisfactory. Where possible, however, the above specification should be used or our advice sought about alternative supplies.

A practice in some parts of the country is to saw trees almost through and leave them standing until snedding out. This method allows Fomes in before the creosote is applied, particularly when the trees are leaning, and is thus objectionable from the Fomes point of view.

To repeat, the aim must be copious, complete and immediate application of the creosote. It is a simple operation but its effectiveness will be considerably decreased if it is not done properly.

THE LOSS THAT FOMES CAUSES.

The loss caused by death of trees is more easily measured than that by butt-rot. Without taking into account reduced increment of trees affected by root-rot, but not killed, the average annual loss in Thetford Chase is just under £1 per acre. Losses in second and third thinnings on alkaline sites may exceed £5 per acre per annum however. This contrasts with a protection cost of approximately 10/- per acre per thinning and well justifies the cost of protection.

Although in the past we have had studies of losses caused by Fomes butt-rot in this country in terms of percentage of infection, we have had none of losses in economic terms. Such a study is at present being undertaken at Aberdeen University. In Sweden several investigations have been made into the losses due to Fomes butt-rot and figures taken from one of these are quoted:

Age	Percentage of Trees Rotted.	Percentage of Volume Decayed.	Loss in Pounds per acre.
40 - 50	45	7.3	43
60 - 70	59	11.9	49
60 - 70	86	19.5	88

In another study in Norway spruce, 65 years old, 41% of the trees were decayed and primary damage attributable to decay was estimated to have caused losses per acre of £26 by 1947 and £38 by 1955. Secondary damage resulting from poorer growth and impaired stem form was greater, causing additional losses per acre of £42 and £51 in the two years respectively. Within a period of 5 years, therefore, the total loss per acre rose by over £20. These Swedish figures illustrate the seriousness of the disease. It must be realised that it is the most valuable part of the stem which is damaged. The hidden increment loss due to a damaged root system is difficult to assess and can very easily be overlooked and so also can the economic loss associated with windblow resulting from root-rot which might well become very important in the future.

The really serious losses occur as butt-rot in mature heavily infected stands and it is this which should be remembered in viewing the position when most of our crops are very young and infection is still in the very early stages of development. It takes a long time for infection to build-up and in our new forest areas where Fomes is initially absent, although some significant losses may be expected by the end of the rotation, the really serious losses are to be expected (unless we prevent them) during the second rotation.

WHAT WE WOULD LIKE TO KNOW ABOUT FOMES.

Our research programme on Fomes is devised to answer various outstanding questions. We have been carrying out a survey to find out the present distribution of the disease and to check to what ext it is increasing and spreading into our new forest areas. We have already learned much about what is happening. In butt-rot areas, as in killing areas, the stump is the normal mode of entry of the fungus into crops. Almost any conifer plantation in this country, however isolated, will, during the course of a normal rotation, pick up some Fomes infection, however small. Infection invariably builds up when one conifer crop succeeds another, normally with a marked increase and significant losses in the second rotation. The degree of initial infection is most influenced by the distance from a spore source, i.e. older conifer ground with an established infection. Although build-up in the case of death is rapid, in the case of butt-rot it is slow, though in the long-run of considerable economic importance. Forests including or near to older conifer areas especially are showing distinct signs of build/

build-up and of entry of the fungus into the new plantations. As expected those parts of the country with a history of widespread planting of conifers in the past are the places where present developments are most marked. The distribution of infection has a very good correlation with the distribution of past conifer plantings. Degree of infection and damage vary quite considerably between sites, but the evidence we have points to the development on even the more resistant sites being sufficient in the long-run to justify the cost of protection. The type of land in much of our present planting programme is different from that on which most of the old conifer plantings took place and it is admittedly difficult to judge the future of these new areas from the pattern of development in older plantings; but there is no reason to expect them to remain Fomes free.

We have visited a lot of forests and hope to visit a lot more. In addition we have an extensive experimental programme but we should very much welcome any help or suggestions which you may make from your own experience. We would particularly like to know about any forest where the behaviour of Fomes appears to differ from the findings mentioned here. Have you a forest with an old conifer history but no Fomes development? Have you a plantation where a second rotation conifer crop has not shown an increased rot development as far as you can judge? Have you ever found butt-rot in a first rotation crop where no thinning or similar operations had been carried out? Have you ever found rot infection entering through brashing wounds? Have you any good cases of infection through wound damage, either animal or extraction? Have you come across species in mixture in attacked plantations where one of the species shows resistance? Or rot infections in Abies species, which are often resistant? Have you found any connection between root-rot and the occurrence of windblow? It may be present only in the key (first to go) tree but this makes it none the less significant. Have you any second-rotation crops on acid sites with a rainfall of over 50"? We have insufficient data on this type of site.

Please write and let us know if you have information on any of these matters. A brief note will suffice and please do not hesitate to write even if you are not sure of all the facts.

HOW TO LOOK AT YOUR OWN FOREST.

After reading this edition of Entopath, foresters may ask "What is the prospect of my crops becoming butt-rotted?" This will depend on several factors but at the moment indications are that a fair answer for most cases will be: "quite high in the long run". The susceptibility of the species in the forest is obviously important. For example in areas of pure pine Fomes rot is not normally a problem. At present, many forests are free from infection and may remain so for some time. If your crops are all first rotation and unthinned, you have no worries until thinning operations begin to provide the fungus with a means of entry. The most important factor is the presence of old conifer woods especially larch, either felled and replanted, or still standing. These will provide the sources for spread onto the rest of the forest. If Fomes butt-rot is present in any of your old woodlands then fructifications are almost certainly there too, although they may be hidden and not apparent at a casual glance. Although stumps from past crops may have been cut many years previously, this is no safe-guard as Fomes is capable of remaining active for decades within them, and can continue to fructify. If you have no such areas within your forest boundaries, there may be adjacent private woodlands which are equally significant. The best indication of butt-rot development is provided in second-rotation conifer areas, as thinnings from these soon reveal the activities of the fungus either as stain or as rot in the stems.

The relative susceptibility of species can also be used as an aid to detection, for trees such as Tsuga heterophylla and Thuja plicata show stain and rot at a much earlier age than the more resistant Douglas fir.

If you have no old conifer woodlands and none occur in the immediate vicinity, the next most likely indicators are the plantations that were first thinned in the forest history. The stumps in these provide the necessary means of entry for the fungus and may, if old enough, carry brackets or pustules. "Pustules" are small, white, circular rubbery growths, which appear on infected stump surfaces. They are most usually found under the litter which accumulates on these stumps. Normally, 2-3 years or longer elapse before spore infection of a stump results/

results in the production of a bracket, but pustules may be produced in as many months. The progress of the disease from an infected stump into neighbouring standing trees is a longer process. Normally something like 10 years elapses before staining is noticed in thinnings around an infected stump.

Former agricultural land now afforested is among the first to show the presence of infection once thinnings have started. The conditions on these sites are conducive to the development of Fomes and greatly accelerate the growth of the fungus.

Briefly then the forests in most urgent need of protection are those where there are sources of Fomes spores in the immediate neighbourhood, and where there are large areas of conifers coming into, or already in the early stages of thinning. Any areas which have ever been under plough should be regarded as particularly dangerous and be given high priority.

FOMES IN PRIVATE WOODLANDS.

There are no doubt a number of private estates where protection measures could be advised. Since however, we are only now beginning to introduce protection into Forestry Commission areas as a whole it is too early to consider any general recommendation for private owners. But in individual cases where there are already some indications of bad development or where help is sought, it should be possible to offer advice.

First there are two general points which are applicable to any private estate or, for that matter, any Commission area. Any sites which have ever been subject to agricultural tillage should be protected. Secondly the striking degree to which Tsuga is attacked on old conifer ground, makes it unwise to plant it on such ground no matter what its Fomes history is.

Generally/

Generally for private estates, as for our own forests, it would be quite proper to protect all plantations now, leaving out only certain specific exceptions such as permanent pine forest not subject to Fomes death. At this stage, however, a controlled introduction is called for, dealing only with the clear and more urgent cases. If on a private estate or near it there is an old conifer area with infection already sufficiently established to form a substantial spore source, then there is need to consider protection. Since private forest plantations are often on the less acid ground, where development of Fomes tends to be worse, there are no doubt many instances where a firm case for protection could be made.

A Forest Record will shortly appear consisting mainly of a study of specimen forests in relation to Fomes development. Need for protection will be discussed in relation to the latter and these cases may serve as criteria in assessing the Fomes problem on private estates as well as in Commission plantations. We cannot ourselves undertake general advisory visits to private estates in this respect but we would advise in any case of particular difficulty.

OTHER CONIFER BUTT-ROT FUNGI.

Only two other butt-rot fungi are of importance at present on conifers - Polyporus schweinitzii and Armillaria mellea. Neither is nearly so serious as Fomes annosus, but both show signs of becoming more important in the future.

Polyporus schweinitzii, which causes considerable damage in North America and is now very widespread in this country, has already shown that it can cause more rapid damage than Fomes. Its future development will require careful watching. We do not know whether P. schweinitzii normally enters through stumps, but there is a chance that our protection measures against Fomes may control P. schweinitzii also.

Armillaria rot has, so far, been restricted to old hardwood sites. It generally causes more limited damage than the other two. We shall probably find more of it as more old hardwood sites are planted up with conifers.

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The descriptions of Fomes and Armillaria are well covered in Leaflets No.5 and 6, but notes are given here on Polyporus schweinitzii. The first symptom of infection is a staining of the timber. In Sitka spruce this is yellowish and can sometimes be followed ahead of the decay area in long conical fingers. In larch the stain is darker, while in Douglas fir it is brownish-yellow. The rot varies a little between species and according to whether it is in an early or advanced stage. In all species the final stages have a typical dry, dark brown cuboidal appearance. The wood breaks easily into large irregular but straight-sided pieces and readily crumbles between the fingers. The cracks are filled with sheets of yellowish mycelium. In earlier stages of rot, especially in Sitka spruce the wood becomes yellow, soft and cheesy or crumbly, and when freshly cut has a strong distinctive smell, which some people think is reminiscent of turpentine. In Douglas fir the early rot stages show a light brown colouration, which soon darkens as the decay advances. Small radial furrows or scores are present at this stage.

The fruit body, which is usually produced in August or September, is irregularly plate-like. It usually appears on the ground near the base of an infected tree but occasionally occurs on the butt of the tree itself. It is roughly circular and sometimes grows in tiers of three or four. Viewed from the top it appears as a dark rusty-brown circular plate, sunken in the centre, with a pale yellow margin when in active growth. The top is soft and furry and the Americans call it the "Velvet-top fungus". On the underside the mouths of the tubes are pale greyish-green, turning red when bruised. They do not appear as neat circular pores, as in the Fomes bracket, but are very irregular in outline. A short, thick stalk is occasionally, but not always, present.

In America, P. schweinitzii is considered by Boyce to be by far the most serious butt-rot of conifers. Fortunately in this country it is much less serious, though it is quite common, occurring in places as far apart as Somerset and Ross-shire. It has repeatedly been noticed that there is a strong correlation between its appearance and the occurrence of old Scots pine ground, and to a lesser extent old hardwood sites. In this country it causes decay in several species, including Sitka and Norway spruce, Japanese and European larch, and Douglas fir as well/

well as old Scots pine. It is unfortunate that it occurs most frequently on Douglas fir, which is one of the trees showing high resistance to decay by Fomes annosus. It has very seldom been recorded as a butt-rotter on young and pole-stage trees, but recently it has been found in several places decaying poles less than 30 years of age.

One of the most threatening aspects of P. schweinitzii is the extent of the damage it can cause in the tree. In Sitka spruce especially, it has been found extending for 8-12' up the stem, with the rot occupying three-quarters of the cross-sectional area at the base; this was in 25-30 year-old stems. This is considerably worse than the damage usually done by Fomes, and is one of the main reasons why P. schweinitzii must be regarded as a potentially dangerous butt-rotter.

Parasitic activity by Armillaria mellea, the symptoms of which are described in Leaflet No.6, is always associated with a sufficient and suitable food supply, usually hardwood stumps. In every instance of Armillaria butt-rot noted recently, the only common factor is the presence of old hardwood material, usually oak. Death of roots and superficial decay of the stem are better-known aspects of Armillaria attack; examples of true butt-rot inside the stems have been found, but decay does not extend more than 18" - 24" up the stem, though the presence of secondary fungi sometimes increases this. This occurs on various types of soil and is not restricted to any one species, having been noted in pole-stage Thuja plicata, Tsuga heterophylla, Sitka spruce, Norway spruce, European larch and Abies species. The most common occurrences were on Norway spruce and Sitka spruce. Douglas fir, on the other hand, is markedly resistant.

The scale of attack is much less alarming than in the case of Fomes. During thinnings all that may be found is an occasional stained or rotted tree, or sometimes a small group of two or three. On a few occasions it has been more widespread with damage occurring over several acres.

There are few outward indications to show that a tree is infected by Honey fungus. The root system contains a proportion of dead roots and under the bark of these, the thick, creamy-white, fan shaped felts of mycelium, or possibly rhizomorphs,

may/

may be found. Resin is usually freely produced on infected roots and may sometimes bond the enclosing soil into a hard crusty mass. Above ground level there may be some resin flow from the lower butt. Swelling of the butt is not a reliable feature.

Decay due to Honey fungus damage is not serious or widespread, but the development of both this fungus and Polyporus schweinitzii in our new plantation will certainly require study in the future.

TAILPIECE.

It has been suggested that we ought to have followed the popular journals of to-day by offering some kind of gift with our special number. We might have sent you a free Fomes fruit body. Possibly we could have made this number a 'Do it yourself' one, with instructions as to how to start your own outbreak, or we could have offered prizes for the best-decayed plantation.

But seriously we have set before you what we consider to be the biggest pathological problem facing forestry in Britain. Before long, stump treatment, which will alleviate this problem, (though it certainly will not do away with it), will probably be started in your Conservancy. In some cases of course it has already been introduced. We hope we have made it clear why it is being done. The results of stump treatment are not immediately apparent. In many cases a long period will elapse before the benefit to the crop, and of course to subsequent crops, can be seen. Please do not let that discourage you. Protection of the crop means protection of the site. Fomes is a spreading menace and at present we have no eradication measures to recommend once a site is infected. Thus in view of the limited land area available for forestry it is important that the long term nature of stump protection should be appreciated. Your successors, who will inherit the plantations you have protected, will we believe have good reason to be thankful to those of you who carried out stump treatment carefully and conscientiously. Please try to think of it, not as a special temporary emergency measure, but as a normal forest operation, like weeding or brashing. And if any practical difficulties do arise or if you feel in need of any further advice, please remember that we at Alice Holt are here to help.

Dr. Myles Crooke has recently returned from a long visit to Canada. As the whole of this number has been devoted to Fomes we have had to postpone an account of his entomological experiences there until our next issue.